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The BLACK HILLS BEETLE

A SERIOUS ENEMY OF ROCKY MOUNTAIN PINES

1939

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THE PERIODIC WIDESPREAD EPIDEMICS OF the Black Hills beetle have been responsible for the destruction of more merchantable pine timber in the Rocky Mountain region than has any other agency.

This tiny beetle kills healthy, vigorous pines of practically all ages and of all species that occur within its range. It kills trees by attacking the trunks and thus introducing blue-staining fungi which cut off water conduction to the leaves, and by destroying the soft inner bark through which they get their nourishment.

When everything is favorable for the developing broods of this insect it increases rapidly from endemic to epidemic status and, unless unfavorable climatic conditions quickly reduce the outbreak, artificial control becomes necessary. The Black Hills beetle requires only 1 year for development, and it should be remembered it is too late to treat trees after the foliage has turned red. The beetles and new broods will be found in pines whose foliage has not begun to turn.

This bulletin describes the insect and its work, its seasonal history and habits, and the methods that have been employed to prevent and suppress outbreaks.

Washington, D. C. Issued July 1939

THE BLACK HILLS BEETLE, A SERIOUS ENEMY OF ROCKY MOUNTAIN PINES

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HISTORY AND EXTENT OF DAMAGE

THE BLACK HILLS BEETLE (*Dendroctonus ponderosae* Hopk.) is one of the most aggressive and destructive of bark beetles and is undoubtedly the most serious enemy of pines throughout the central Rocky Mountain region. During outbreaks this insect attacks vigorous, healthy trees, and frequently, as a result of its destructive work, extensive stands of pine timber are practically wiped out.

The first major outbreak on which observations were made occurred in the Black Hills of South Dakota from 1895 to 1908, inclusive, and it was here that the beetle acquired its name. During this epidemic between 1 and 2 billion board feet of ponderosa pine timber was killed. On the Kaibab National Forest in northern Arizona, during the years from 1917 to 1925, inclusive, this beetle killed in excess of 300,000,000 board feet of timber. An outbreak on the Roosevelt National Forest in northern Colorado, occurring between 1923 and 1930, killed an estimated total of 100,000 trees but was successfully brought under control in 1930. A serious outbreak on the Montezuma and Uncompahgre National Forests in southwestern Colorado during 1933 to 1936 was brought under control in 1936. Some 20,000 ponderosa pines were treated during this operation, but this number represents only a part of the loss, for many of the trees killed early in the outbreak were not counted. From about 1932 to the present time a very aggressive outbreak has been in progress on Elk Mountain in southeastern Wyoming, in stands of limber pine and lodgepole pine. Here the loss has averaged about 60,000 trees each year on an area of 15 sections. During the last few years many smaller aggressive outbreaks have been controlled, and others are

still being fought on a number of Colorado and Utah forests. From the earliest observations to the present time a long list of outbreaks of varying intensity and destructiveness have been recorded throughout the range of the Black Hills beetle. Prompt control measures applied to small incipient infestations in recent years have undoubtedly prevented a number of serious epidemics.

The Black Hills beetle occurs in the pine-forested areas of southeastern Montana, western South Dakota, the eastern half of Wyoming, and through Colorado, Utah, New Mexico, and Arizona. It attacks ponderosa, limber, whitebark, lodgepole, piñon, Mexican white and bristlecone pines, and occasionally Engelmann and blue spruces. It seldom produces broods in spruce, however, and these trees need not be treated for this particular beetle. Of these many hosts, ponderosa pine is the preferred one, with limber, whitebark, and lodge-

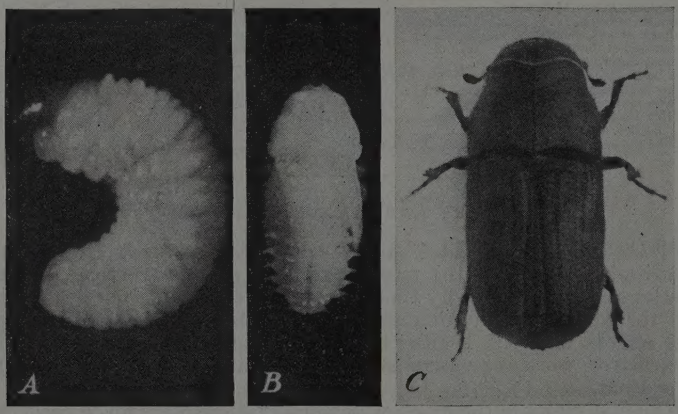

FIGURE 1.—The Black Hills beetle: *A*, Larva, × 8; *B*, pupa, × 6; *C*, adult, × 8. (Photographs by N. D. Wygant.)

pole pines also ranking high. Where other pines occur either in mixture with or close to these, they too are likely to be attacked. The beetle prefers trees 6 inches or more in diameter, and only occasionally during epidemics will it attack smaller trees. During epidemics it also shows a slight preference for the more vigorous, rapidly growing trees.

When the Black Hills beetle is not numerous it breeds in weakened trees or those injured by lightning or in some other way. The beetles are often attracted to places where pines have been cut, trimmed, or pruned during the summer months, or to other locations where a strong pine odor is noticeable. Because of this, when the beetles are numerous, the trimming or otherwise injuring of but a single pine tree in the middle of or late in the summer, at about the time the beetles are in flight, may result in the loss of a number of pines in the immediate vicinity.

If conditions are favorable, the beetles increase very rapidly, and the brood from a single tree may, upon emerging, be sufficient to in-

fest an additional three or four trees. Under these conditions small centers of infestation increase rapidly in number and size, coalescing to form larger groups and causing extensive losses. These epidemics continue until terminated either through natural factors or artificial control methods.

CHARACTER OF WORK

Damage to living trees is caused by the adult beetles and their larvae or grubs (fig. 1). The beetles bore through the outer bark and construct long, nearly straight, vertical egg galleries in the soft

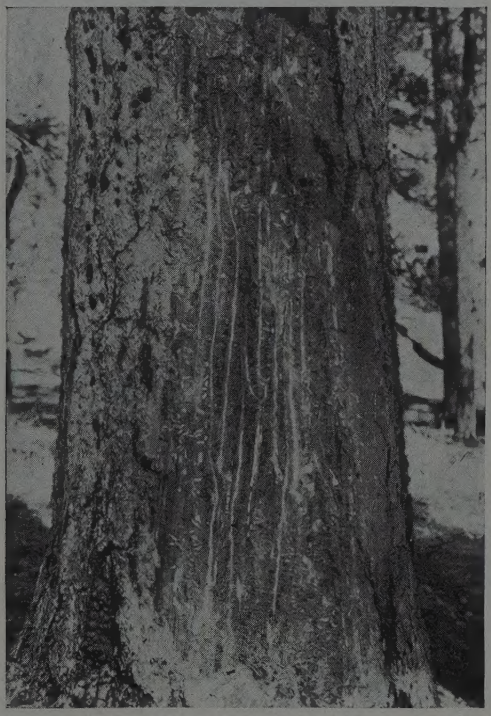

FIGURE 2.—Long, straight galleries made by adults of the Black Hills beetle, shown on wood of infested pine after the removal of the bark. Note characteristic hook at the point of entrance and horizontal larval mines.

inner bark, slightly grooving the wood (figs. 2 and 3). They also carry in certain blue-staining fungi which rapidly permeate the sapwood. Each gallery usually has a characteristic hook at the lower end where the beetle entered the tree. These egg galleries are about three-sixteenths of an inch in width and from 1 to 3 feet long and are packed solidly with boring dust. The young grubs also mine the inner bark but extend their feeding galleries or larval mines more or less horizontally, at right angles to the egg gallery. Fully grown

larvae (fig. 4) construct pupal cells at the ends of the larval mines and there transform to pupae and adults. The young adult beetles usually burrow through the intervening bark between these pupal cells and congregate in a common cavity thus formed. They emerge through small round holes made in the bark, several beetles often emerging from a single hole (fig. 5).

As a result of the numerous galleries constructed in the cambium region beneath the bark and the development of the blue stains in the sapwood, the movement of water from the roots to the leaves

FIGURE 3.—Straight galleries made by adults of the Black Hills beetle in the soft inner bark of pine. Note characteristic hook at the lower end of the galleries (where beetle entered the tree), larval mines, and oval pupal cells along some galleries. Slightly reduced.

is cut off, and the tree is girdled and killed. A large number of beetles are required to kill a healthy tree, and as many as a thousand or more adults may attack a tree of large size. Where only a few beetles attack, the flow of pitch at the points of entrance is usually sufficient to "pitch out" or overcome the beetles, and the tree is not killed. Consequently trees with only a few large pitch masses on the bark and no completed egg galleries under the bark should not be treated in control work.

EVIDENCE OF BEETLE ATTACK

Trees attacked by the Black Hills beetle can be recognized by the small masses of pitch (referred to as pitch tubes) which form on the bark at the mouth of entrance holes (fig. 6), or by the presence of boring dust around the base of the tree and in bark crevices. By closely examining the pitch tubes the point of attack may be found—a tiny circular hole in the bark. Removal of the bark above

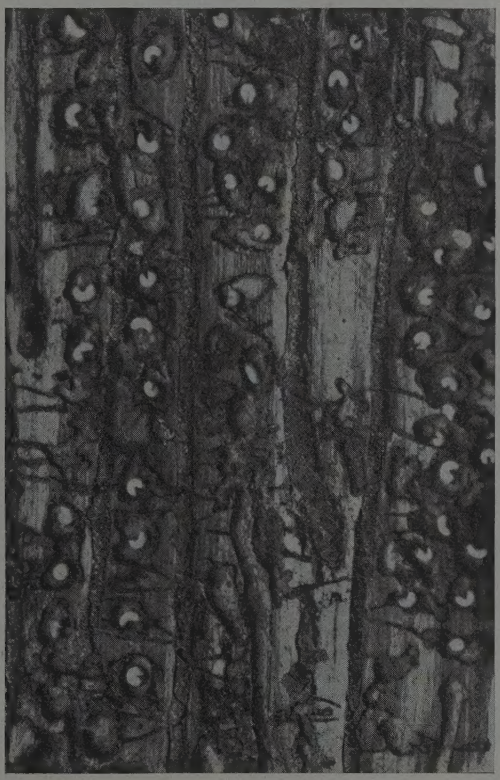

FIGURE 4.—Fully grown larvae of the Black Hills beetle in pupal cells of inner bark of pine. Slightly reduced. (Photograph by N. D. Wygant.)

one of these holes will usually reveal a pair of adult beetles at work at the upper end of their vertical gallery. If the attack is a month or more old, the mines of the young grubs can also be seen extending horizontally from the parent egg gallery. Trees attacked at the normal time in August usually do not fade until the following spring; consequently the only means of detecting infested trees during the fall and winter are the numerous small pitch tubes on the bark, the red boring dust at the base, and the vertical galleries,

tightly packed with frass, under the bark. A blue-stain fungus, which is associated with the beetle in the trees, is carried in by the beetles and spreads rapidly through the sapwood (fig. 7). Heavily blue-stained sapwood is a certain indication that the tree has been killed.

Late in the spring and early in the summer the discoloration of foliage is the best method of locating pine trees attacked by this

FIGURE 5.—Outside of bark of pine tree, showing exit holes made by emerging Black Hills beetles. Because many newly formed beetles often emerge from a single hole, these holes are not necessarily numerous. About half natural size.

beetle the previous summer. Usually by May of the year following the attack some of the infested trees begin to lose the natural dark-green color of their foliage and turn lighter, becoming a pale green. With warmer weather, the foliage turns a yellowish green, followed by a light-yellow or straw color, and finally a reddish brown. The foliage of different infested trees does not change color at the same time, nor is fading necessarily uniform on an individual tree. Usually one or two trees in an infested group will show discoloration first, followed by a gradual color change over the entire group.

The presence of "red-tops," trees having sorrel or brick-red foliage (fig. 8, *A*), usually indicates beetle infestation in the forest. After midsummer, however, these trees ordinarily contain only secondary, associated, and parasitic insects, having already been abandoned by the Black Hills beetle, which requires fresh phloem, or the inner bark of living trees, for development of its broods. The second year after attack the needles begin to fall, and heavily infested areas (figs. 8, *B;* and 9) have a grayish devastated appearance.

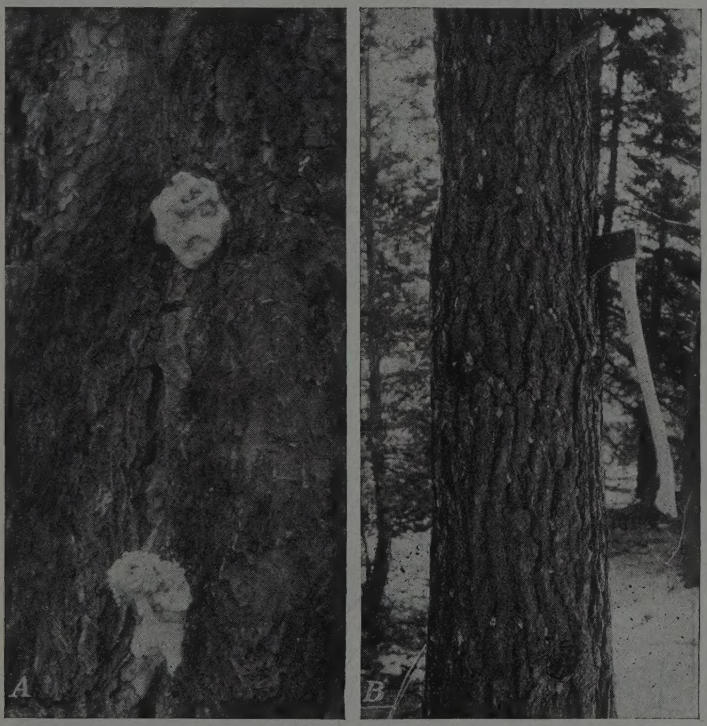

FIGURE 6.—Pitch tubes made by the Black Hills beetle: *A*, About half natural size; *B*, general appearance of pitch tubes along the trunk.

DESCRIPTION OF THE BEETLE

The Black Hills beetle passes through four distinct stages during its life history. These are the egg, the larva, the pupa, and the adult. The adults are small, rather stout, cylindrical beetles, ranging in length from two-tenths to three-tenths of an inch (fig. 1, *C*). When immature they are yellowish to dark brown, but they become black when fully mature. The eggs are small, oval, and pearly white. The larvae (fig. 1, *A*) are white, fat, legless grubs with small brown heads; at maturity they are about the size of the beetles.

The pupae (fig. 1, *B*) are also white and represent the transformation stage between larvae and adults. The appendages found on the adults can be recognized on the pupae.

SEASONAL HISTORY AND HABITS

Most of the life of this insect is spent beneath the bark of the pines in which it works. Only green trees or those with fresh, moist inner bark are attacked by the beetles, and the resulting broods usually require 1 year for development. The beetles emerge and fly chiefly during August. At this time all the faded trees are abandoned, and new, live ones are attacked.

FIGURE 7.—Cross section of a pine tree killed by the Black Hills beetle, showing the associated blue stain extending to the heartwood.

Eggs are laid in niches along the sides of the egg gallery as it is being constructed late in the summer. The eggs hatch in about 10 days, and most of the larvae are half grown before winter. The larvae resume feeding in the spring. During the latter half of May the most advanced larvae begin transforming to pupae, and during the first half of June some of these change to the adult stage. The beetles, however, do not leave the infested, fading trees until most of the brood has matured, or until the middle of summer.

The flight usually starts late in July and continues during August. During this period the beetles fly to nearby green trees and immediately attack them. Dead trees are never attacked, and trees under 6 inches in diameter are seldom infested except during severe epidemics. If the flight is heavy, conditions that develop within a tree after it is attacked may attract a large number of beetles to the

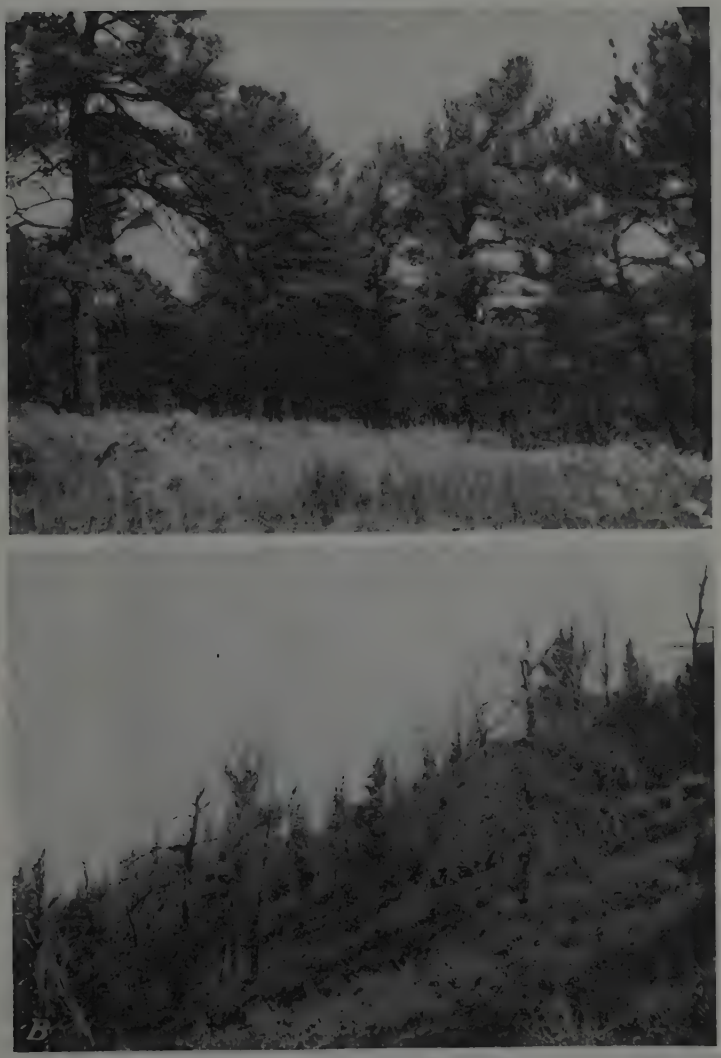

FIGURE 8. Groups of limber pines killed by the Black Hills beetle: *A*, The spring after the attack—the light foliage indicates the fading of the needles; *B*, 2 to 3 years after the attack the foliage has entirely disappeared.

spot and result in the killing of a group of trees. Although a complete generation is usually produced in 1 year, at elevations of between 9,000 and 10,000 feet in the northern limits of the beetle's range a small percentage of the brood sometimes requires 2 years for complete development.

BARK BEETLES LIKELY TO BE MISTAKEN FOR THE BLACK HILLS BEETLE

Several other bark beetles are often associated with the Black Hills beetle, but only a few of those most likely to be confused with this serious enemy of Rocky Mountain pines will be mentioned here.

THE SOUTHWESTERN PINE BEETLE

The southwestern pine beetle (*Dendroctonus barberi* Hopk.) is similar in form to the Black Hills beetle but is smaller, being only

FIGURE 9.—Ponderosa pines in southern Utah killed by the Black Hills beetle. An old attack, as evidenced by loose and falling bark and loss of smaller twigs. (Photograph by Blaine Betenson, Forest Service, U. S. Department of Agriculture.)

one-eighth to three-sixteenths of an inch long. It occurs throughout most of the southern range of the Black Hills beetle. It can be distinguished from this insect by the characteristic S-shaped and winding galleries of the adult (fig. 10). The larval mines are rarely visible on the inner surface of the bark but extend into the outer bark, where the larvae transform to pupae and adults. Because of this habit merely peeling the infested trunks will not de-

stroy the broods; the bark must be burned. The southwestern pine beetle usually attacks overmature, lightning-struck, felled, or weakened ponderosa pines; but on occasion it builds up to a serious condition, and artificial control work becomes necessary. This beetle is often associated with other insects such as the Black Hills beetle.

FIGURE 10.—Winding egg galleries of the southwestern pine beetle. They show in the inner bark and on the wood.

THE COLORADO PINE BEETLE AND THE ROUNDHEADED PINE BEETLE

The Colorado pine beetle (*Dendroctonus approximatus* Dietz) and the roundheaded pine beetle (*D. convexifrons* Hopk.) very closely resemble the Black Hills beetle in size and general appearance. The character of the galleries offers the most reliable means of identification. The Colorado pine beetle constructs short, wind-

ing, many-branched galleries, and the larval mines are not evident on the inner bark. The roundheaded pine beetle excavates long, wavy, or sinuous, longitudinal egg galleries, and the larval mines and some of the pupal chambers can be seen on the inner bark. These two species frequently occur in the same tree or are associated with other species in living, injured, and dying ponderosa pine trees. While it is recognized that they may occasionally attack and kill healthy trees, they usually prefer weakened trees or those previously attacked by other insects and generally are not important.

THE RED TURPENTINE BEETLE

The red turpentine beetle (*Dendroctonus valens* Lec.) is similar in appearance to the Black Hills beetle but of a reddish color and larger, being one-fourth to three-eighths of an inch long. It usually attacks the living bark on the basal portion of injured, dying,

FIGURE 11.—Characteristic group killing of pole-size pine by one of the engraver beetles, *Ips oregoni*. (Photograph by L. G. Baumhofer.)

healthy, or felled pine. It more often works in fresh stumps and the lowest 3 or 4 feet of trees attacked by other insects. The beetles excavate broad, irregular, longitudinal galleries, placing their eggs in groups along the sides, and the larvae feed gregariously.

THE ENGRAVER BEETLES

Three species of *Ips*[1] are often found associated with the Black Hills beetle. They are all normally secondary insects, breeding by preference either in fresh slash, felled or broken trees, or those recently killed by more aggressive insects. During particularly dry years some of these beetles may increase and, unaided by other insects, kill groups of drought-weakened trees (fig. 11). Occasion-

[1] *Ips knausi* Sw., *I. integer* (Eichh.), and *I. oregoni* (Eichh.).

ally when they develop to large numbers in slash they will emerge and attack a group of adjacent, young, green trees. However, they do not continue to breed in green trees and are not of primary importance.

These engraver beetles, or *Ips* species (fig. 12, *B*, *C*, *D*), can be distinguished from the Black Hills beetle (fig. 12, *A*) by the form of the body and by the type of gallery they make. The chief difference between the insects is seen in the form of the hind end of the body. In the Black Hills beetle this is gradually rounded off in a convex manner, whereas in the *Ips* bark beetles it is scooped out and armed on both sides of this depression with minute toothlike projections.

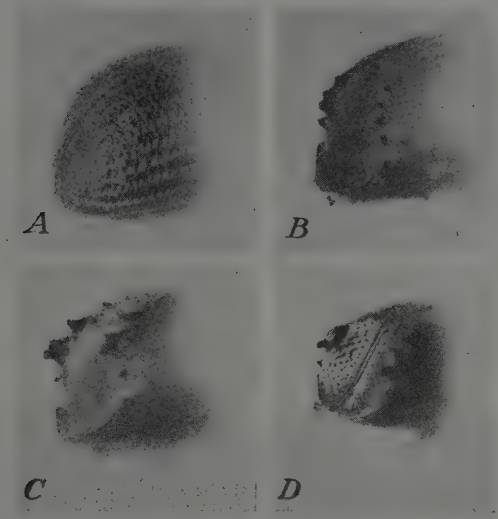

FIGURE 12.—View of hind end of adult bark beetles: *A*, The Black Hills beetle (note end of body gradually rounded off in a convex manner); *B*, *C*, and *D*, corresponding parts of *Ips* bark beetles showing hind end of body scooped out and armed with toothlike projections. (Photographs by N. D. Wygant.)

The egg galleries of *Ips* beetles have several branches radiating from a central point and are kept free from boring dust (fig. 13, *A*, *B*), whereas those of the Black Hills beetle are characteristically hooked at the lower end, long and straight, and always tightly packed with frass or boring dust (fig. 2). The grubs of the *Ips* beetles feed in the inner bark, where they develop to maturity, as is the case with the Black Hills beetle.

OTHER BEETLES ASSOCIATED WITH THE BLACK HILLS BEETLE

Many other insects besides the bark beetles are found in trees killed by the Black Hills beetle. Chief among these are the round-headed borers or larvae of large cerambycid beetles.[2] They are com-

[2] *Acanthocinus spectabilis* Lec., *A. obliquus* Lec., *Monochamus maculosus* Hald., *Asemum atrum* Esch., and *Tetropium velutinum* Lec.

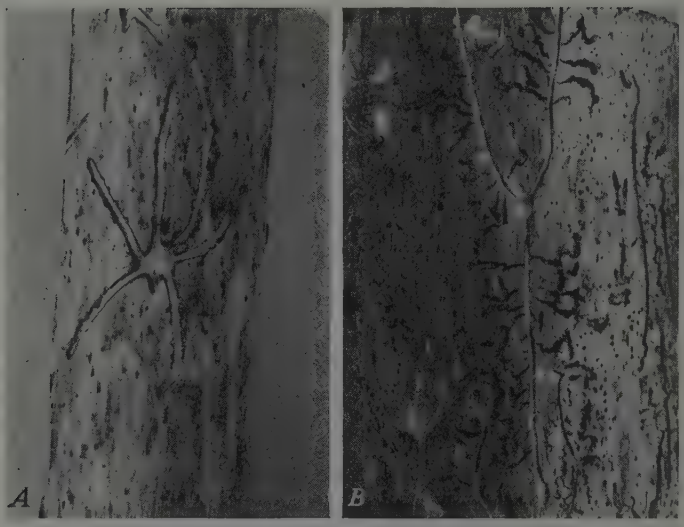

FIGURE 13.—Galleries of the engraver beetle *Ips oregoni: A*, The beginning of a gallery, showing the nuptial chamber, a six-branched gallery, and egg niches along the gallery; *B*, a three-branched gallery further advanced, showing larval mines.

FIGURE 14.—*A*, Larval mines of roundheaded borers in the inner bark of pine; *B*, large larvae of roundheaded borer in the inner bark of pine and smaller larvae and pupae of the Black Hills beetle in pupal cells.

monly called sawyers or fish bait. The adults are large grayish or blackish beetles, and some have long feelers, or antennae. The larvae are white, elongated, legless grubs ranging from ½ to 1 inch in length. They are in no way responsible for the death of the trees, but they mine the wood of infested trees and reduce its value for lumber. These insects feed for a time in the same part of the inner bark as that required by the bark beetle brood (fig. 14). Thus they compete with the bark beetles for available food and probably destroy many of those with which they come in contact. Because of this habit they are sometimes called robbers.

NATURAL ENEMIES OF THE BLACK HILLS BEETLE

Although there are several kinds of natural enemies of the Black Hills beetle, such as insect parasites, insect predators, robbers, and birds, these are probably more important during endemic years, when few beetles occur, than during epidemic years. Several small wasp-like parasites and small predacious flies have been reared from broods infesting lodgepole pine and limber pine, but very few have been noted in ponderosa pine. The larvae of several species of predacious clerid beetles feed on the brood of the Black Hills beetle beneath the bark. Some of the cerambycid larvae, as robbers, sometimes kill large numbers of the brood as they feed through the inner bark of infested pines. Woodpeckers feed on the brood at times (fig. 15), but more often prefer the larger cerambycid larvae. The mountain bluebird and a nuthatch have been reported feeding heavily upon the adults during the flight period.[3]

Unfortunately these agencies are not present in our forests in large enough numbers to prevent or suppress outbreaks, and there is no known method of increasing their effectiveness.

PREVENTIVE MEASURES

Some species of destructive bark beetles show a decided preference for mature or overmature trees, and this fact can be made use of in the management of timber stands. This, however, is not true of the Black Hills beetle, for, while this beetle does choose the more slowly growing or weakened trees under endemic conditions of infestation, no such choice is evident during an epidemic. In fact, the trees killed by the beetle in large-group killings are often found to have been growing more rapidly than those not attacked.

Logging operations during the flight period undoubtedly remove a great many beetles from the woods, since the beetles are often attracted to freshly felled logs. In this connection it is worthy of note that there is no record of a serious infestation of this beetle ever having been built up in or near an area where continuous logging was in progress.

It is easier and far less costly to prevent serious outbreaks of the Black Hills beetle than to bring them under control after they have

[3] The Bureau of Biological Survey of the U. S. Department of Agriculture has made a study of the food of birds by examining the contents of the stomachs of large numbers of them. They report that the following have fed on insects of the genus *Dendroctonus:* Nighthawk, chimney swift, white-throated swift, Lewis's woodpecker, hairy woodpecker, American and Alpine three-toed woodpeckers, olive-sided flycatcher, white-breasted nuthatch, dipper, Bewick's wren, hermit thrush, yellow-throated and blue-headed vireos, American magpie, and English sparrow.

made considerable headway. The best way to do this is to keep a careful watch of forest areas in which epidemics may develop. Pine forests in the Rocky Mountain region should be examined periodically. Where infested and dying pine trees in groups of even three to five are found they should be examined for evidence of the Black Hills beetle. Observations should also be made on the extent of killing in the area. Where this insect appears to be on the increase, a systematic survey should be made to determine the need for control work. If any doubt

FIGURE 15.—Work of woodpeckers searching for larvae of the Black Hills beetle and other grubs in an infested tree.

exists as to the identity of an insect found infesting trees or as to the advisability of control, specimens, together with complete information concerning the infestation, should be sent to the Forest Insect Laboratory, Bureau of Entomology and Plant Quarantine, Fort Collins, Colo.

CONTROL MEASURES

Before control work against the Black Hills beetle is considered in any particular forest area a general reconnaissance examination should be made to determine the location, nature, and extent of the infestation. This can best be done by the topographic or red-top survey method where a large part of the forest can be viewed from open

valleys, ridges, or lookout points. This examination should take into consideration not only the currently infested trees on the area but also the number of "red-top" trees as well. Since the trees with considerable red foliage usually indicate the amount of infestation the previous year, a comparison of their number with the number of newly infested trees will show the trend of the infestation, whether it is increasing, decreasing, or merely holding its own. Some trees retain part of their needles for two or three seasons, and it is necessary to distinguish those from trees killed the season prior to the examination. Some further idea of how many emerging beetles may be expected may be obtained by felling a number of infested trees early in the summer and noting the number of live brood beneath the bark.

If control measures are advisable, the general examination should be followed by a survey, or cruise, to determine more accurately the boundaries of the infestation, to locate the areas of damage, and to obtain an estimate of the number of trees requiring treatment. Without such a survey it is difficult to organize the control work efficiently and effectively. The extensive survey should be conducted by the sample-strip method. In using this method the observer travels along compass lines, pacing the distance, and counting the infested trees on a strip of designated width (usually 1 chain wide). On large areas involving many thousands of acres in the lodgepole pine type, a 1¼-percent survey will usually give a fair estimate of the total number of infested trees. On smaller areas a relatively more extensive survey is necessary for an accurate estimate. On extensive areas of ponderosa pine a 2½-percent survey is usually required for comparable results, because of fewer trees per acre, and where only a few thousand acres are involved a survey of between 5 and 10 percent is advisable.

In the lodgepole pine type, if the survey shows an aggressive infestation where groups of three to five infested trees are found and they average as much as 64 trees per section, control work should usually be undertaken, especially where the timber is of economic importance or adjacent valuable pine stands are threatened. In the ponderosa pine type, however, control work is undoubtedly advisable with a much smaller number of infested trees per section, on account of the much larger size of the trees and the relatively small number per acre. Under forest conditions an infestation in this type should usually be treated if it includes as many as 20 trees per section, particularly if the infestation is increasing. In highly scenic areas or where trees have a high aesthetic or other great value, control work is warranted in a much lighter infestation. In many such cases even occasional individual infested trees should be treated.

When control work is undertaken the infested area should be fully covered by spotters, assigned to locate and mark all infested trees (fig. 16). The blazed trees should be numbered and marked on a map, so that they can be readily found by the treating crews. Spotters should be carefully trained to recognize the trees that need treating and to differentiate between them and those with old attacks, or pitched-out attacks, which should not be treated. The success of the project often depends in a large measure on the ability of the spotters and their success in locating and marking all infested trees and in leaving the uninfested ones. Of course their work must be followed by that of well-organized, efficient control crews.

Control work directed against bark beetles is aimed at the destruction of the immature stages of the insects before they have abandoned the infested trees. The main object is to destroy as nearly 100 percent of the infestation as is physically possible. Any method that will bring about the desired result may be used, but the one best adapted to local conditions peculiar to the area to be treated should be selected.

LOGGING

Where concentrated infestations occur in valuable pine timber accessible to lumber markets, control work can often be done at relatively little cost and sometimes even with a small profit. The infested trees are felled, cut into log lengths, and transported to the

FIGURE 16.—Pine trees newly infested by the Black Hills beetle being marked for treatment. Attacks are frequently made on the better growing, more vigorous trees.

mill, where they are sawed into lumber and the slabs containing the insects burned. It is essential that these slabs be burned several weeks prior to the emergence period of the beetle. The bark on all infested portions of the trees remaining in the woods, such as stumps, long butts, large crooked top logs, large limbs, etc., must either be peeled while the insects are in the larval stage, or be burned before the beetles emerge.

This method is not applicable in either inaccessible areas or scattered infestations or in timber stands of low commercial value. Lumber cut from beetle-infested pines is usually badly stained by the fungus introduced by the beetles and because of this blued condition is frequently not accepted for some uses. The prejudice against blue-stained lumber for structural uses or for finishing where the surface is to be painted is unjustified, for such lumber retains its normal strength and is just as serviceable as unstained lumber.

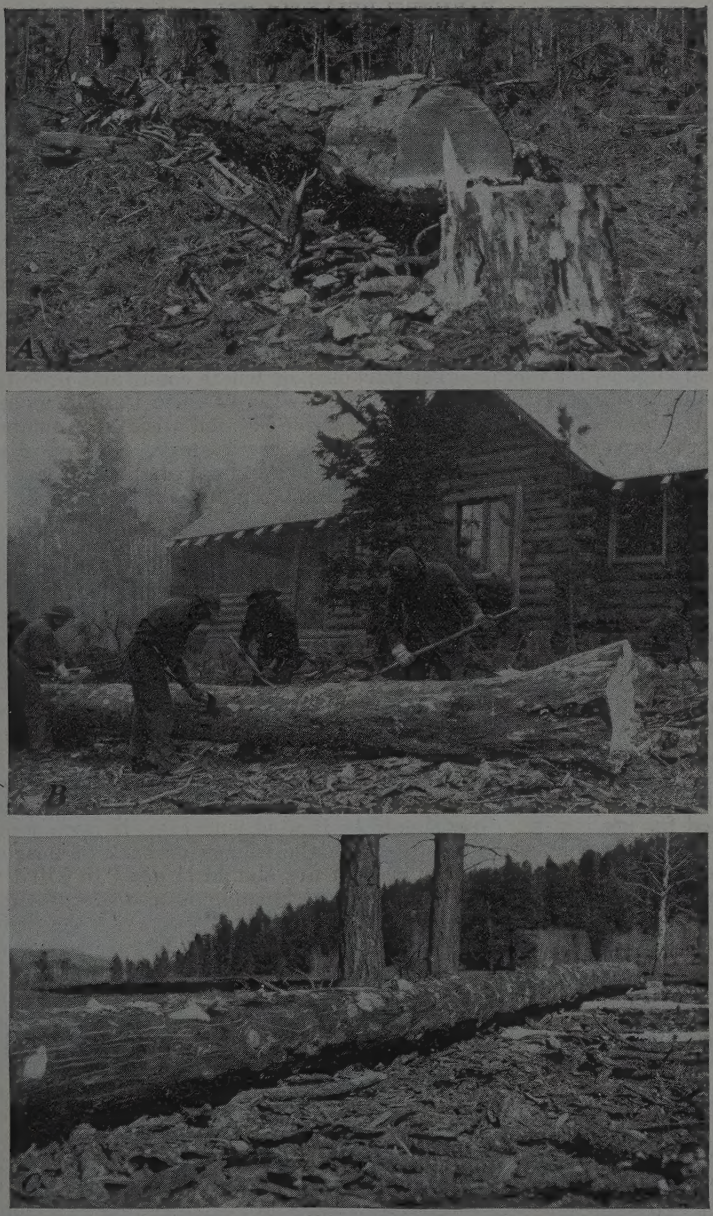

FIGURE 17.—Destroying broods of the Black Hills beetle: *A*, A single infested pine felled and prepared for burning as soon as conditions are safe for fire; *B*, treating an infested pine by the felling and peeling method (note peeling tools, or spuds, being used); *C*, an infested tree treated by the felling and peeling method. Note the galleries of the Black Hills beetle on the wood. (*A* and *C* photographed by Blaine Betenson.)

PEELING THE INFESTED BARK

Another method is to fell the trees while the broods are in the larval or grub stage and remove all the bark from the infested portions of the bole, stump, and base of large limbs, by the use of either axes or spuds (fig. 17, *B* and *C*). The uninfested upper bole, above the highest beetle gallery, need not be peeled. This part of the tree is usually filled in by *Ips* beetles during the spring, but these should be disregarded. Peeling turns the developing broods out of their natural surroundings beneath the bark, and they dry out and die or are consumed by other insects such as ants, or by mice or birds. Short trees or those containing broods only near the ground can sometimes be peeled with long-handled spuds without being felled. The peeling method can be used whenever it is desirable to save the treated boles for fuel or other purposes, or where conditions prohibit the use of fire. It must, however, be used only when the insects are in the immature stages and should never be used when any number of the brood have reached the adult or beetle stage. The effective period for peeling extends through the fall, winter, and early part of spring, usually from the middle of September to the first of June.

BURNING

Infested trees can be felled and burned. The burn should be sufficient to char the entire bark, and thus insure a complete kill of all the brood (fig. 18). It is advisable to buck small trees into short sections so they can be decked and burned (fig. 18, *A*). Sometimes trees can be felled parallel and close together or skidded together so they can be burned in a group without being sawed into shorter lengths. Trees too large to be handled in this way can be burned where they fall, by piling dry sticks, limbs, and brush along the sides and top of the trunk to insure a good burn (fig. 17, *A*). Hacking the bark along the top side of the tree trunk also insures a better job of burning on this often-difficult part and eliminates the need for peeling it. Fires should be located with care, in open spots if at all possible, so as not to scorch the foliage or bark of nearby trees or reproduction. Only enough fire should be used to kill the insects beneath the bark, as additional burning is a waste of time and money. The correct degree of burning will vary with the project and the weather conditions from day to day. The project foreman should keep a close watch of all treating activities and handle the work according to the conditions. Fire lines should be raked around each deck, group, or single tree before the fire is started and the debris thrown on the fire. Every precaution must be used to prevent such fires from spreading.

Burning costs about the same as peeling but successfully disposes of most of the slash. If burning conditions are safe, it can be used as a control measure from the time the trees are attacked until just prior to the time the beetles fly the following summer. Fires cannot be used indiscriminately, however, for some areas become too dry to permit burning, and careless use of fire often results in serious browning of nearby green trees. When it becomes unsafe to use fire in control work, peeling can be resorted to up to the time the brood begins to transform to the adult or beetle stage early in June.

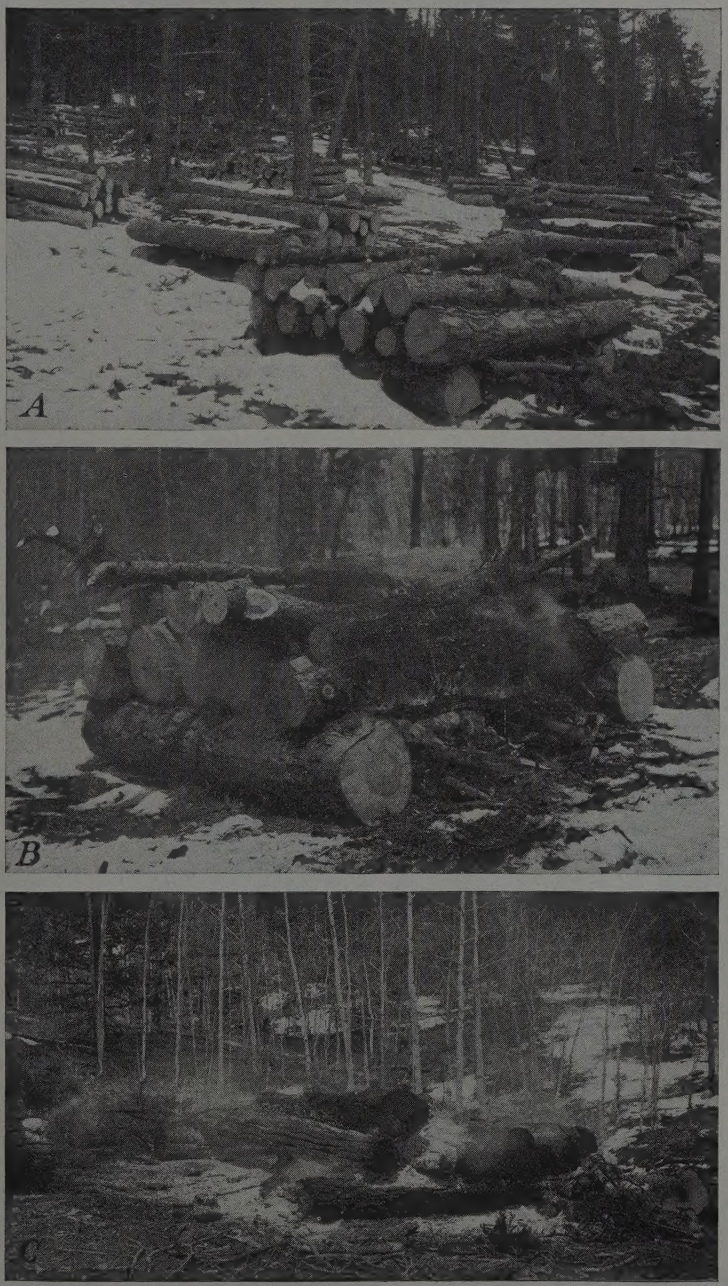

FIGURE 18.—Destroying broods of the Black Hills beetle by burning: *A*, Infested pines felled, bucked, and decked for burning; *B*, burning the logs; *C*, thoroughly charred logs.

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